Arid Land Research and Management 17: 469–478, 2003

ISSN: 1532-4982 print/1532-4990 online
DOI: 10.1080/15324980390225548

Breeding Improved Grasses for Semiarid Rangelands

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Vast areas of semiarid rangelands in western USA are severely degraded and infested with troublesome weeds such as cheatgrass (Bromus tectorum) *and medusahead rye* (Taeniatherum asperum). *Reseeding with appropriate plant materials that are adapted to the site and competitive enough to replace existing undesirable vegetation is often the most plausible way to reclaim such sites. Unfortunately, many of our native grasses are more difficult to establish and are not as competitive with these exotic weedy grasses as their introduced counterparts, including crested and Siberian wheatgrass* (Agropyron cristatum, A. desertorum, *and* A. fragile). *Most native grasses did not evolve under intense management or in association with species as competitive as cheatgrass. Genetically improved germplasms and cultivars of native and introduced (naturalized) grasses have been and are being developed by the Forage and Range Research Laboratory (FRRL) of the United States Department of Agriculture-Agricultural Research Service (USDA-ARS) in cooperation with the Utah Agricultural Experiment Station (UAES) and other agencies. These plant materials have demonstrated the potential for increasing the genetic diversity, protecting watersheds and soil resources, and improving the habitat and grazing potential for livestock and wildlife on semiarid rangelands. Research is also in progress at FRRL to develop germplasm and methodology whereby introduced grasses may be used in combination with natives, and in some instances assist in the establishment of native stands. The proper choice of plant materials must be based on objective criteria if we are to protect our lands and natural resources from further degradation.*

Keywords plant breeding, range grasses, range improvement, range seeding, improved cultivars, cheatgrass, crested wheatgrass, *Agropyron* spp.

Reliable range monitoring procedures confirm that a large portion of western America's semiarid ranges are badly depleted and infested with undesirable weedy grasses and/or forbs. Reseeding these areas with suitable and genetically improved plant materials is often the most plausible approach to their reclamation. The appropriate plant materials to be used in these reclamation efforts depend on

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environmental factors and ultimate use of the site, as well as political or environmental concerns.

Introduced grasses such as the crested wheatgrass [*Agropyron cristatum* (L.) Gaertn. and *Agropyron desertorum* (Fisch. ex Link) Schultes], Siberian wheatgrass [*Agropyron fragile* (Roth) Candargy], intermediate wheatgrass [*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey], and Russian wildrye [*Psathyrostachys juncea* (Fisch.) Nevski] have made valuable contributions to rangeland improvement; however, these species have become the focus of considerable debate among environmental, political, research, and user groups. Some are concerned that these introduced grasses reduce biodiversity by displacing native species and disrupting the ecology and aesthetics of the plant community in other ways as well. Support for these contentions has led to government policy restricting the use of introduced plant materials on many public lands.

A blanket ban against all nonnative germplasm is not justified. We propose that adapted introduced grasses be considered along with native grasses in seed mixtures for seeding on environmentally harsh sites that have been burned, infested with competitive weedy species, or otherwise degraded. Many introduced grasses, particularly those that have been extensively used in past revegetation programs, have demonstrated superior stand-establishment characteristics, hardiness, wide adaptability, and productivity compared to their native counterparts (Asay et al., 2001; Barker et al., 1977; Vallentine, 1977; Kilcher & Looman, 1983; Lawrence & Ratzlaff, 1989)). In addition, seed of these species is usually more readily available and at a lower cost. Introduced grasses also have demonstrated the capacity to adapt through natural selection to the environmental conditions on sites where they have been seeded. Thus, after some generations of natural reseeding, a naturalized and better adapted derivative of the original population inhabits the site.

Cheatgrass (*Bromus tectorum* L.) has been and remains a major factor in deterioration of the ecological balance, natural resources, and productivity of western rangelands of North America (Young & McLain, 1997). Cheatgrass has become so widespread that virtually all sagebrush (*Artemisia* spp.)/bunchgrass ranges in the Intermountain West are now infested with this noxious weed. These rangelands become much more subject to recurrent fires that ultimately remove all native woody plant components from the plant communities thereby perpetuating cheatgrass dominance and loss of valuable soil resources.

If cheatgrass is to be successfully controlled, it must be replaced with a perennial grass or forb. Little progress has been made to this end, partially because most efforts have been confined to the use of native species. Native grasses and forbs are important sources of plant materials in rangeland reseeding operations, and progress has been made in providing genetically improved native germplasm. However, most of these grasses did not evolve in plant communities comprising species as competitive as cheatgrass or in the presence of domestic herbivores. It is not surprising then that most of these grasses do not compete well with weeds like cheatgrass, particularly at the seedling stage of plant development. Introduced (or naturalized) grasses such as crested and Siberian wheatgrass have that inherent advantage, and improved cultivars of these species have shown even greater potential to compete with and replace cheatgrass on semiarid rangelands. Young & McLain (1997) concluded, and we must concur, that not to consider the use of these potentially valuable grasses because they are not native is to condemn much of our rangelands to weed dominance and often disastrous loss of our soil resources.

It is noteworthy that most of the important introduced grasses used in our range improvement programs have thrived and continue to do so in biologically diverse ecosystems in their native habitats. In our research at the U.S. Army Training Facility near Yakima, Washington, native bluebunch wheatgrass has infiltrated and successfully coexisted with Siberian wheatgrass that was seeded to range sites more than 15 years earlier (Asay et al., 2001). On the basis of these and other similar observations, we are confident that an introduced grass could be used as an "ecological bridge" to establish native species on difficult sites. For example, an introduced grass with superior seedling-establishment characteristics could be used to initially revegetate a cheatgrass-infested site. A native perennial grass that is better adapted to the long-term environmental conditions of the site than the introduced grass could either be included in the seed mix or seeded later. As the stands of the less adapted introduced grass decline, the adapted native grass moves in.

The Forage and Range Research Laboratory (FRRL) of the United States Department of Agriculture - Agricultural Research Service (USDA-ARS) is working in cooperation with the Utah Agricultural Experiment Station (UAES) and the USDA-Natural Resource Conservation Service (NRCS) to develop genetically improved native and introduced perennial grasses, legumes, and forbs to be used in upgrading range and pasture lands in the Intermountain West. Several cultivars and germplasms released from this research program have had a major impact on rangeland improvement efforts. Emphasis herein will be given to these plant materials; however, we recognize that work is also underway at other USDA-ARS locations, notably Mandan, ND, and Lincoln, NE; and by other agencies including the USDA-NRCS and the USDA-Forest Service (FS).

Improved Cultivars and Germplasms

Hycrest Crested Wheatgrass

This vigorous cultivar was developed from a hybrid between an induced tetraploid ($2n = 2x = 28$) of Fairway (*Agropyron cristatum*) and the natural tetraploid Standard (*A. desertorum*) crested wheatgrass (Asay et al., 1985a). It is the first interspecific hybrid of crested wheatgrass to be released and tends to be more robust than either of its parental species. In evaluation trials on several representative range sites, it has established stands more rapidly and produced significantly more forage than the cultivars Nordan or Fairway, particularly during the first two years after seeding. Hycrest is a winter-hardy, drought resistant bunchgrass. The cultivar is well adapted to sagebrush and juniper (*Juniperus* spp.) vegetation sites with annual precipitation from 200 to 400 mm. It is best adapted to elevations from 1500 to 2200 m and to a wide range of soils, but does particularly well on sandy to sandy loam soils. It will not tolerate prolonged flooding but is moderately tolerant of saline soils.

CD-II Crested Wheatgrass

The breeding population for CD-II was derived from the interspecific hybrid cultivar Hycrest (Asay et al., 1997). Original selections were made from a Hycrest foundation seed-increase block consisting of 40,000 spaced plants. Selection was based primarily on early spring growth, vegetative vigor and absence of purple leaves during the early spring, tolerance to diseases and insects, forage yield, and leafiness. CD-II has been distinguished from Hycrest on the basis of Random Amplified Polymorphic DNA (RAPD) fingerprinting profiles. It produced significantly more forage under cold temperatures in controlled environment growth chambers than Hycrest. On semiarid sites, establishment vigor, forage yield, and persistence have been comparable to Hycrest and significantly greater than the check cultivars Nordan and Fairway, particularly during, and immediately following, establishment. CD-II produces abundant forage during the spring and early summer, and its area of adaptation is similar to Hycrest. Unlike Hycrest, CD-II is protected under the Plant Variety Protection Act, which stipulates that Certified Seed can be produced from the Foundation Class only.

Douglas Crested Wheatgrass

Douglas is the first hexaploid ($2n = 6x = 42$) cultivar of crested wheatgrass to be released in North America (Asay et al., 1995a) and is characterized by its broad leaves. It was named in honor of Douglas R. Dewey, who established the germplasm base for the USDA-ARS grass breeding program at Logan. During the development of Douglas, selections were made primarily for broadleaf types, vegetative vigor, seed yield potential, resistance to plant pests, seed size, and stand-establishment vigor. Douglas has larger seeds than diploid and tetraploid cultivars, and exhibits excellent establishment vigor under field conditions. Although it produces less total forage than other crested wheatgrasses, it is leafier and it's broad leaves remain green for a longer period during the growing season than other crested wheatgrass cultivars. Grazing animals often prefer Douglas to other crested wheatgrass cultivars. It is not as drought resistant as the cultivars Vavilov, Hycrest, and Nordan. Douglas is recommended for range sites receiving at least 250 mm of annual precipitation at altitudes below 2200 m. The cultivar is protected under the Plant Variety Protection Act, and Certified Seed can be produced from the Foundation Class only.

Vavilov Siberian Wheatgrass

The cultivar Vavilov was derived from accessions received from VIR, Stavropol Botanical Garden, Stavropol, Russia; the Eskisehir Plant Breeding Station, Eskisehir, Turkey; and selections from the cultivar P-27 (Asay et al., 1995b). The cultivar was named to recognize the contribution of the N.I. Vavilov Research Institute of Plant Industry, St. Petersburg, Russia (VIR) to the germplasm resources of the USDA-ARS range grass breeding program. The parental breeding population was selected repeatedly for vegetative vigor, response to drought, resistance to diseases and insects, seedling vigor, seed yield, and a leafy plant type. Seedling vigor of Vavilov, as indicated by establishment in field trials and seedling emergence from deep seedings, is comparable to the cultivar Hycrest and is consistently better than the Siberian wheatgrass cultivar P-27. It produces significantly more forage than P-27 in most evaluation trials. Vavilov typically has linear, narrow, and relatively long spikes, although some gradation between the shorter and wider spikes characteristic of the Standard form is evident in the population. Vavilov retains its greenness longer and is more drought resistant than either Standard or Fairway and is better adapted to sandy soils than any other crested wheatgrass. Vavilov is an excellent seed producer and is highly recommended for semiarid range sites with sandy soils that receive from 200 to 400 mm of precipitation annually. Vavilov is protected by the Plant Variety Protection Act with the requirement that Certified Seed must be developed from Foundation Seed.

RoadCrest Crested Wheatgrass

RoadCrest, a rhizomatous cultivar of crested wheatgrass, was developed from two accessions originally obtained from Turkey (Asay et al., 1999). The parental populations were subjected to selection pressure to intensify their rhizomatous growth habit as well as for fine leaf texture, short growth stature, and improved seedling vigor. RoadCrest is a long-lived perennial tetraploid, and is significantly more rhizomatous than any other crested wheatgrass included in evaluation trials. It produces less biomass and is from 15–25% shorter in stature than forage-type crested wheatgrass cultivars. Seedling vigor and drought resistance of RoadCrest compares favorably with other crested wheatgrasses, including Hycrest, CD-II, Fairway, and Nordan. RoadCrest is significantly easier to establish and initiates growth earlier in the spring than other turf and low-maintenance turf grasses; however, leaf color and turf quality of RoadCrest are not as good as Kentucky bluegrass (*Poa pratensis* L.), tall fescue (*Festuca arundinaceae* Schreb.), or perennial ryegrass (*Lolium perenne* L.) when the latter grasses are grown under optimum conditions. RoadCrest greens up early in the spring and remains green until midsummer on temperate sites; plants then go dormant until temperatures decline and soil moisture improves in the fall. Summer dormancy is much less prominent at elevations above 2000 m. RoadCrest is recommended for use along roadsides or similar low-maintenance turf applications in temperate, semiarid regions receiving from 250 to 450 mm of annual precipitation. Seeding rates should be from 15 to 25 kg ha^{-1}, which is substantially less than rates recommended for other turf grasses. As with other crested wheatgrass cultivars, supplemental irrigation can actually be a detriment if total water application (precipitation + irrigation) exceeds 550 mm. Release of an improved derivative of this cultivar is anticipated in year 2006.

Bozoisky-select Russian Wildrye

Bozoisky-select is a winter-hardy, drought resistant, bunchgrass that is widely adapted to semiarid rangelands. It was derived from germplasm obtained from the former Soviet Union (Asay et al., 1985b) and has since become the predominant Russian wildrye cultivar in the Intermountain Region. During its development, selection was based primarily on traits associated with seedling and vegetative vigor, tolerance to abiotic and biotic stress, leafiness, and seed yield. Russian wildrye is native to the steppe and desert regions of Russia, Kazahkstan, and China. Its range of adaptation is similar to crested wheatgrass and performs well with 200 to 400 mm of annual precipitation. Bozoisky-select has excellent drought tolerance and does well in a variety of vegetation types including sagebrush (*Artemisia* spp.), juniper (*Juniperus* spp.), shadscale [*Atriplex confertifolia* (Torr. & Frem.) S. Wats], and greasewood [*Sarcobatus vermiculatus* (Hook.) Torr.] ecosystems. It is best adapted to loam and clay soils and is moderately tolerant of saline soils. Bozoisky-select is an excellent source of forage during the spring and summer, and because its leaves cure relatively well during the fall, it is often used for grazing during the late fall and winter. Although it has improved seedling vigor compared to other diploid cultivars, it is more difficult to establish than grasses such as crested wheatgrass. Planting depth should never exceed 1.8 cm.

RWR-Tetra-1 Tetraploid Russian Wildrye

RWR-Tetra-1 germplasm was developed and released as source material for genetic studies and for the development of improved cultivars of tetraploid Russian wildrye (Jensen et al., 1998). Tetra-1 was developed from collections made in Kazakhstan in 1988. This germplasm has significantly heavier seeds, greater seedling vigor, taller stature, and longer and wider leaves than standard diploid Russian wildrye cultivars and the tetraploid cultivar Tetracan. The parental accessions were found to have better water-use efficiency than the diploid cultivars as determined by C isotope discrimination measurements, and they were similar to diploid cultivars in forage and seed yield, phenological development, and forage quality. The population has been and is currently being screened for vegetative vigor, seed size, forage yield, and response to biotic and abiotic stresses. We anticipate that an improved tetraploid cultivar will be released from this germplasm in 2004.

NewHy—RS Hybrid Wheatgrass

NewHy was derived from a hybrid between quackgrass [*Elytrigia repens* (L.) Nevski] and bluebunch wheatgrass and released in 1989 (Asay et al., 1991). It is now described as *Elymus hoffmannii* (Jensen & Asay). Although the initial hybrid was meiotically irregular (Dewey, 1976) and only partially fertile, a moderately fertile population was achieved after five generations of selection. Selections were then made to combine the vigor, productivity, salinity tolerance, and persistence of quackgrass with the drought resistance, caespitose growth habit, seed quality, and forage quality of bluebunch wheatgrass. Compared to quackgrass, the cultivar is only moderately rhizomatous on range sites receiving 300 to 400 mm annual precipitation. It is noteworthy that NewHy did not spread beyond its plot borders into adjacent plots in evaluation trials. NewHy has demonstrated excellent resistance to excess soil salinity, approaching that of tall wheatgrass [*Thinopyrum ponticum* (Podp.) Barkworth & D. R. Dewey]. Forage quality is similar to that reported for intermediate wheatgrass. However, NewHy begins growth early in the spring and retains more succulent and palatable forage for livestock and wildlife later in the growing season than other wheatgrasses. The hybrid is resistant to moderate grazing pressure after establishment but it regrows more slowly than pasture grasses such as orchardgrass (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinaceae* Schreb.) following cutting or grazing. An ongoing recurrent selection program is underway to increase the salinity tolerance of NewHy. Exceptional progress has been made and a new salt-tolerant variety of NewHy is in the field testing stage prior to a projected release in 2006.

RS-H, RS Hybrid Wheatgrass Germplasm

RS-H was derived from a collection originally made in Turkey. It is considered to be a natural hybrid between two species from the genera *Elytrigia* and *Pseudoroegneria* (Jensen et al., 2003). Because of its morphological and genomic similarities with NewHy, RS-H is also treated as *Elymus hoffmannii*. Although the original RS-H collection was predominantly rhizomatous, approximately 5% of the plants were nearly caespitose. The population was subjected to several generations of selection to increase the frequency of genes conditioning the caespitose growth habit. The present RS-H germplasm is substantially less rhizomatous, taller in stature, and has longer leaves than NewHy. Salinity tolerance, forage quality, and area of adaptation of RS-H are similar to NewHy. It begins growth early in the spring, and its leaves remain green and succulent longer in the growing season than most other wheatgrasses. Genetic variability observed in the RS-H population indicates that it will be an excellent source of germplasm for breeding salinity tolerant cultivars for use on semiarid sites (300 to 450 mm annual precipitation) and pastures with limited irrigation potential. RS-H qualifies for commercial production as a tested class (prevariety) seed.

M-5 Altai Wildrye

Altai wildrye [*Leymus angustus* (Trin.) Pilger] was introduced from Asia but relatively little breeding work has been done on it. Altai wildrye is productive and has considerable potential for grazing during the fall and winter, but it is difficult to establish on range sites. The M-5 breeding population was developed from a selected Asian collection after successive cycles of selection for characters related to stand establishment. This strain has performed exceptionally well in evaluation trials, and breeding work with it and other hybrid combinations involving *Leymus* germplasm (Jensen et al., 2002). A formal release of M-5 Altai wildrye is expected in fall 2003.

P-7 Bluebunch Wheatgrass Germplasm

Bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) A. Löve] is a valuable perennial grass in the sagebrush steppe environments of the Intermountain and western

Great Plains regions of the United States and Canada. This long-lived bunch grass is highly regarded for livestock and wildlife grazing. Suitable bluebunch wheatgrass germplasm is badly needed for restoration of multiple-use semiarid rangelands where stands have been depleted by overgrazing, invasive species, and fire. P-7 bluebunch wheatgrass germplasm was developed to provide the genetic diversity within a single germplasm for a wide range of semiarid to mesic sites where bluebunch wheatgrass was an original component of the vegetation (Jones et al., 2002). P-7 was released as a selected class of certified seed (genetically manipulated track). It is a multiple-origin polycross generated by intermating 25 populations (23 native-site collections and two cultivars, Whitmar and Goldar) from Washington, Oregon, Nevada, Utah, Idaho, Montana, and British Columbia. Sixteen of the 25 component populations are predominately awned and nine are awnless (Larson et al., 2000). Because the awnless genetic trait is dominant and awned is recessive in bluebunch wheatgrass and its relatives (Jones et al., 1991), most plants in the P-7 population are awnless. Three generations, G-0 (the separate 25 populations), G-1 (first intermating), and G-2 (second intermating) will be maintained by FRRL at Logan, Utah. Seed of the G-2 generation will be made available to growers for production of G3 and G-4 seed. Sale of P-7 seed beyond the G-4 generation is prohibited to limit genetic shift.

Rimrock Indian Ricegrass

Indian ricegrass [*Achnatherum hymenoides* (Roem. & Schult.) Barkw.] is a perennial, cool-season bunchgrass found on soils that are neutral to mildly alkaline, with low water holding capacity, low clay content, high bulk density, and with few rock fragments. The grass is distributed from the Nebraska sand hills west to the eastern slopes of the Cascade and Sierra Nevada range, and from Mexico to Canada at elevations up to 3000 m. Indian ricegrass is recommended for use in seed mixtures for range revegetation and reclamation of disturbed sandy soils. Indian ricegrass produces an abundance of plump seed that provides excellent high-protein food for birds, wildlife, and livestock. When planted adjacent to taller plants, this grass provides an excellent habitat for a wide variety of livestock and wildlife.

Rimrock Indian ricegrass was released by the USDA-NRCS in cooperation with the Agricultural Experiment Stations of Montana and Wyoming, and the USDA-ARS, FRRL (Jones et al., 1998a). The accession was collected about 1 km north of Billings, Montana, on a sandy range site that is approximately 1100 m above sea level and receives from 250 to 350 mm annual precipitation. After extensive evaluation by the USDA-NRCS at Bridger, Montana, it was released directly without selection. During its evaluation, Rimrock was found to retain mature seed better than other cultivars, hence facilitating mechanical seed harvest and retention of seed longer during shattering events such as high winds and heavy rain. Its seed retention capability is associated with a more acute angle between its glumes and the appendages subtending the seed. Foundation seed is available from the USDA-NRCS at Bozeman, Montana.

Ribstone Indian Ricegrass

Ribstone Indian ricegrass germplasm has been released as a prevariety germplasm (genetically manipulated track) by FRRL, the UAES, and Ducks Unlimited-Canada. The germplasm was derived from an accession collected near Taber, Alberta. Like "Rimrock," Ribstone exhibits high seed retention. Seed of the G-1 generation (original accession) will be maintained by FRRL, and seed of G-2 and G-3 generations will be made available to growers by Ducks Unlimited-Canada and the Utah Crop Improvement Association. Seed through the G-4 generation will be eligible for certification, but sale of Ribstone seed beyond generation G-4 is prohibited.

Sand Hollow Big Squirreltail

Sand Hollow big squirreltail [*Elymus multisetus* (J. G. Smith) Davy germplasm] was released to assist in reclamation of rangelands in the Snake River Plain and northern Great Basin subject to high frequencies of wildfires (Jones et al., 1998b). Sand Hollow's intended use is to reclaim and restore rangelands dominated by exotic annual weedy grasses that fuel fires and to assist in ecological succession. The original collection was made in Gem County, Idaho, on a site with a Lolalita loamy coarse sand (coarse-loamy, mixed, nonacid, mesic, Xeric Torriorthents) on a west-facing slope (35%) at 830 m elevation. Estimated average annual precipitation at the site is 280 mm. Sand Hollow is adapted to sandy soils throughout the Snake River Plain in southern Idaho and in adjacent regions to the south, east, and west in Idaho, Oregon, Nevada, and Utah. No intentional selection was practiced on the original accession, therefore Sand Hollow was released as a selected class of certified seed (natural track). The FRRL will maintain G-2 seed (two generations beyond the original collection), and G-3, G-4, and G-5 seed will be eligible for certification.

Toe Jam Creek Bottlebrush Squirreltail

This germplasm of bottlebrush squirreltail [*Elymus elymoides* (Raf.) Swezey ssp. *californicus* (J.G. Sm.) Barkworth, comb. nov. ined.] is pending release as a selected class (natural track) by FRRL in cooperation with the UAES, USDA-NRCS, and the USDA-Bureau of Land Management (BLM). This accession (PI 531604) was collected in northwestern Elko County, Nevada, about 13 km west of Tuscarora. Elevation at the collection site is 1830 m and average annual precipitation 312 mm. Toe Jam Creek's intended area of use is the northern Great Basin and the lower Snake River Plain.

Fish Creek Bottlebrush Squirreltail

This accession is being released as a selected class (natural track) of prevariety germplasm by FRRL in cooperation with the UAES, USDA-NRCS, and USDI-BLM. Fish Creek was collected in Blaine County, Idaho, and no intentional selection has been practiced within the advanced generations of the accession. Estimated average annual precipitation at the site is 380 mm, and the elevation is about 1450 m. Fish Creek's intended area of use is the upper Snake River Plain.

Cucharas Green Needlegrass

This green needlegrass [*Nassella viridula* (Trin.) Barkw.] germplasm has been released as a selected class (natural track) of prevariety germplasm by FRRL and the UAES. The original accession was collected near Walsenburg, Colorado (elevation 1830 m), and no intentional selection has been practiced. The intended use for this germplasm is in the central Great Plains.

Summary

We have emphasized perennial range grasses that were released and are being developed by FRRL in cooperation with the UAES and other agencies. Germplasm releases also have been made with other legumes and forbs. These include Deseret alfalfa, *Medicago sativa* L. (Pedersen & Griffin, 1977), ARS 2678 kura clover, *Trifolium ambiguum* M. Bieb. (Rumbaugh et al., 1991), ARS 2936 Scarlet globemallow, *Sphaeralcea coccinea* (Nutt.) Rydb., and ARS 2892 Munroe globemallow, *Sphaeralcea munroana* (Douglas ex Lindl.) Spach ex A. Gray (Rumbaugh et al., 1993a, b). Additional information regarding these and other plant materials can be found on the FRRL web site (http://www.usu.edu/forage/frrl.htm). Active plant breeding programs are also in progress at FRRL with dryland alfalfa (*Medicago* spp.), birdsfoot trefoil (*Lotus corniculatus* L.), sainfoin (*Onobrychis viciifolia* Scop.), kura clover, forage kochia [*Kochia prostrata* (L.) C. Schrad.], meadow brome (*Bromus riparius* Rehm.), tall fescue, and orchardgrass.

A comprehensive description of grass cultivars for range and pasture lands is provided by Alderson and Sharp (1994). A description of plant materials released by NRCS and their cooperators through September 2002 is given by Davis et al. (2002) and on their web site (http://plant-materials.nrcs.usda.gov). This information is updated annually.

It is evident that excellent plant materials are available for rangeland improvement programs, and more are under development. However, we must recognize that environmental conditions and species composition in natural rangeland ecosystems are continually changing. Hence, restoration of the vegetative composition of a site to its original state (whatever that was) is like aiming at a moving target. Restoration may not be possible, and it is clearly not the best alternative on many sites. In choosing the appropriate plant materials, we must first consider conservation and enhancement of our soil resources. Land managers must use objective criteria in choosing the best plant materials to reclaim weed-infested lands, maintain biodiversity, provide forage and habitat for livestock and wildlife, and meet the other multiple demands that are placed on rangelands.

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